RHIC pp RUN5 Performance

Mei Bai

Collider Accelerator Department
Brookhaven National Laboratory

Outline

- The Goal of pp RUN5
  - **Provide collisions at 100 GeV with longitudinal polarization at STAR and PHENIX**
  - **Explore the polarized proton acceleration beyond 100 GeV**
- The performance of RUN5
  - Timeline of the run
  - What has been achieved
    - 100 GeV program
    - 205 GeV development
- What have we learned
  - Issues during pp RUN05
- Outlook for RUN06

Timeline

- Machine setup:
  - Injection setup: 6 shifts
    - Circulating beam, optics/orbits
    - Most of the beam instrumentation
  - Ramp development: 40 shifts
    - 7 bunch ramp development: 10 shifts
      - Orbit corrected to the flat orbit
      - Tunes were adjusted
      - Decoupling
        - Replace the skew quad in sector

	Before	After
bi5-qs3	0.004	0.0
yo5-qs3	-0.00094	-0.00026

        - Skew quad modulation

Timeline

- Machine setup:
  - Ramp development: 40 shifts
    - 56 bunch ramp: 21 shifts
      - Orbit corrections
      - Tuning optics
      - Collision setup
      - Polarization measurement
    - polarization improvement:
      - Snake current scans at injection
      - Before the yellow polarimeter max energy was properly set
        - Swap the yellow tune settings along the ramp (1 shift)
        - Switch ideal orbit to zero orbit: 8 shifts (4/13 – 4/16)
      - Yellow CNI polarimeter problem fixed

Timeline

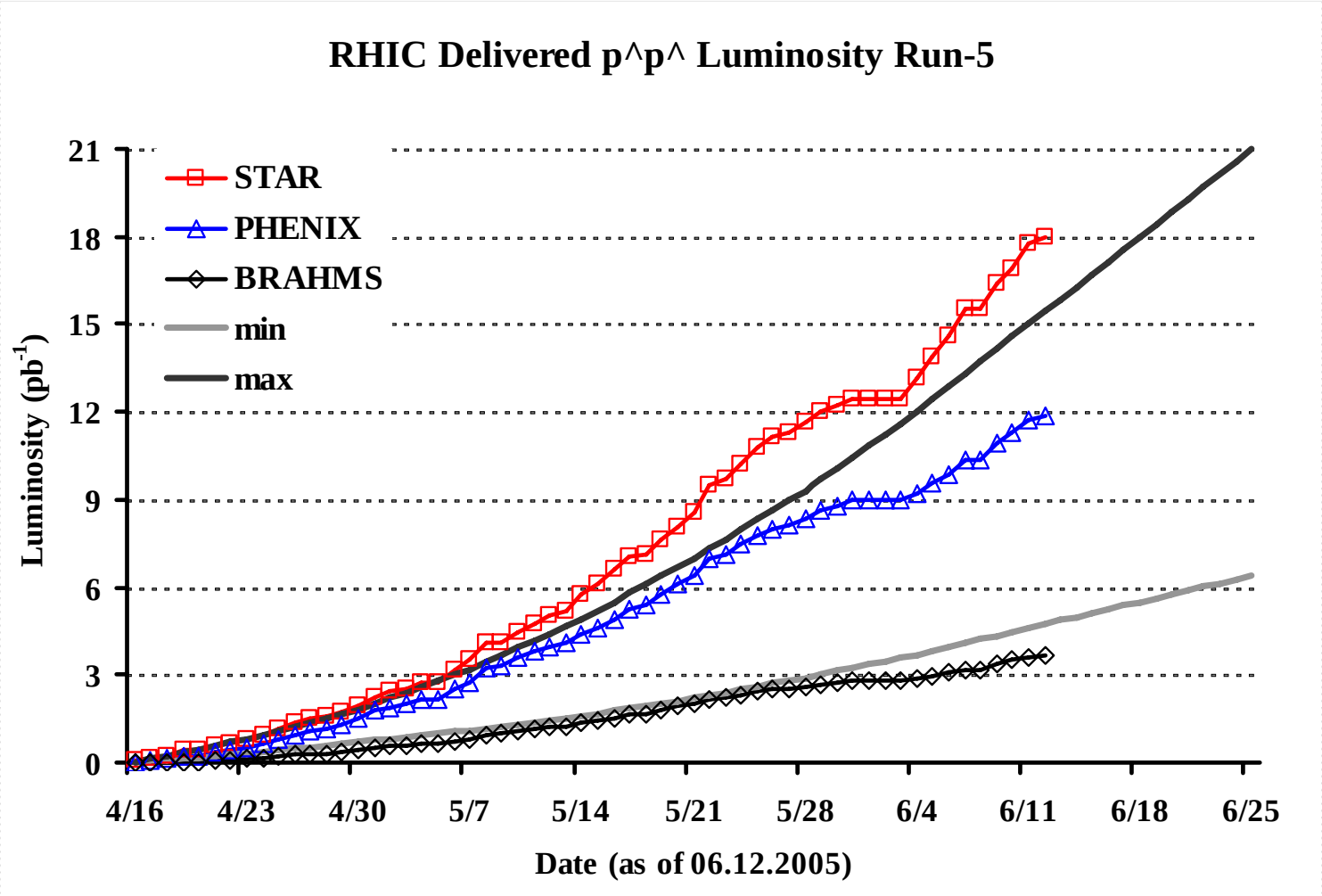
- Physics established + machine ramp-up phase
  - Main problems
    - Beam loss during beta squeeze
      - Increase separation bumps
    - Emittance blowup during ramp
      - Increase chromaticity to avoid zero crossing
    - Emittance blowup during store
      - Yellow polarization measurement
      - Chromaticity crossing zero
    - Yellow lifetime at store
      - Tight dynamic aperture: no storage cavity ramp-up at store
        - A factor of 3 smaller than Blue
    - STAR background issues
    - Yellow polarization sensitive to the target position
      - polarization profile

Overall performance

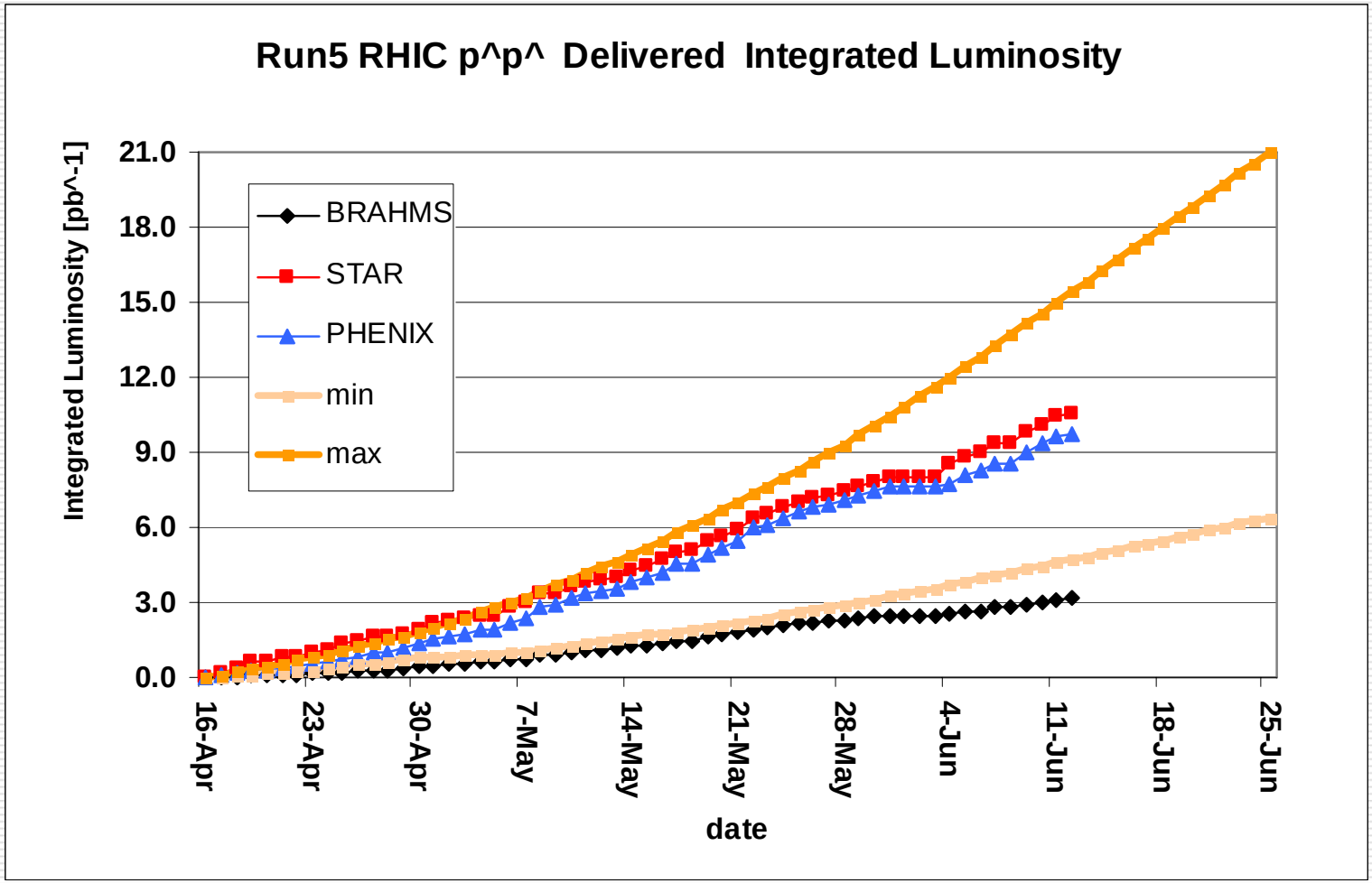
	Bunch intensity $X10^{11}$	# of Bunches	$\mathcal{L}_{peak}$ $X10^{30}$ $cm^{-2}s^{-1}$	$\mathcal{L}_{store}$ $X10^{30}$ $cm^{-2}s^{-1}$	$\mathcal{L}_{week}$ pb^{-1}	Machine uptime	Pol at Store Blue/Yellow
FY04	0.7	56	5.4	4.0	--	--	40%
FY05 min	0.7	56	5.4	4.0	0.9	40%	40%
FY05 max	1.0	79	16	8.2	3.0	50%	45%
FY05 operation	1.0	84	9.0	4.9	1.2	52%	48.5/43.5
FY05 max	1.12 (61 bunches)	110 ($0.95x10^{11}$ protons/bunch)	13	8.2	1.8	--	61.9/58.4

Projection

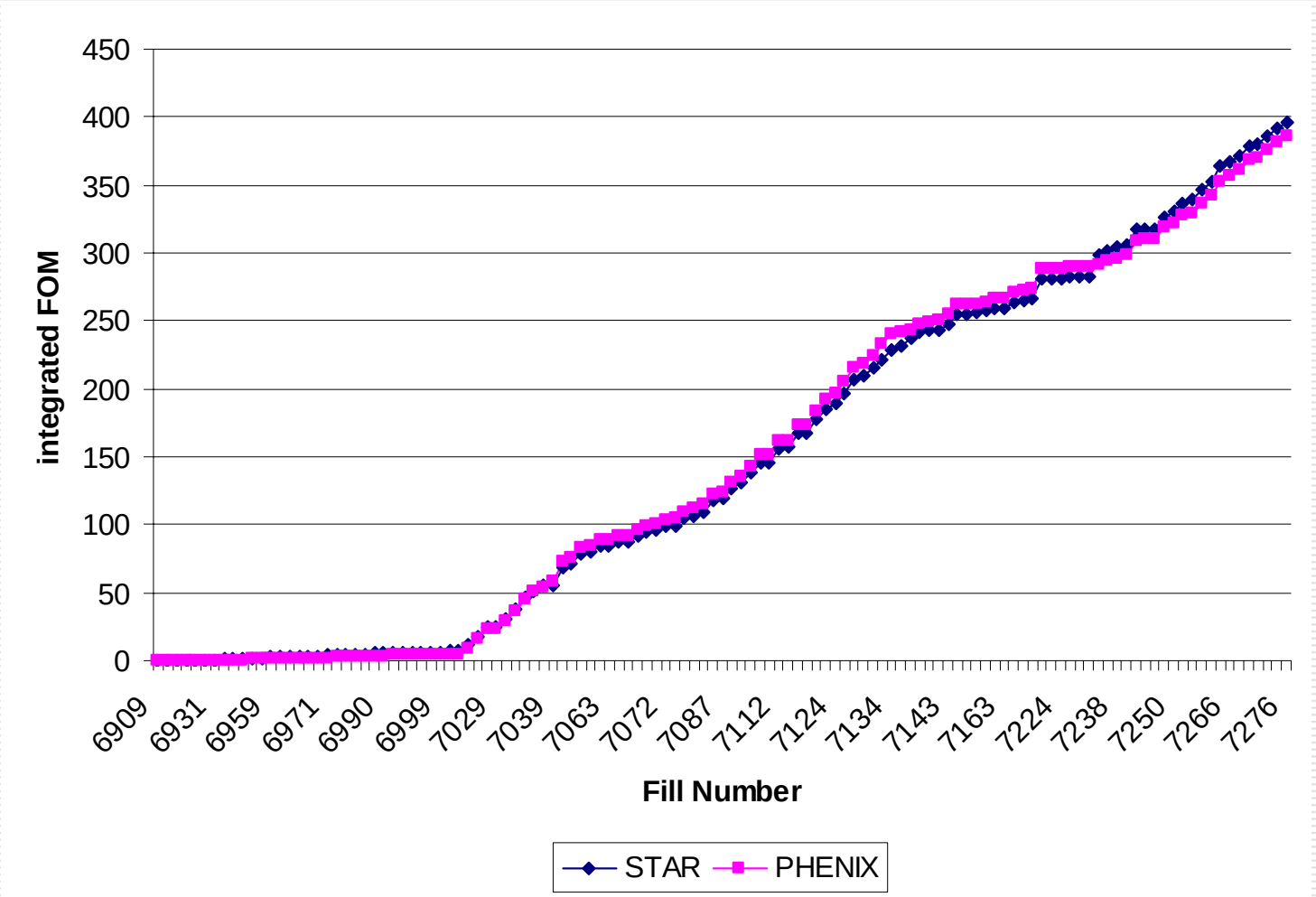
RHIC integrated luminosity: ev-lumi-on ~ ev-lumi-off



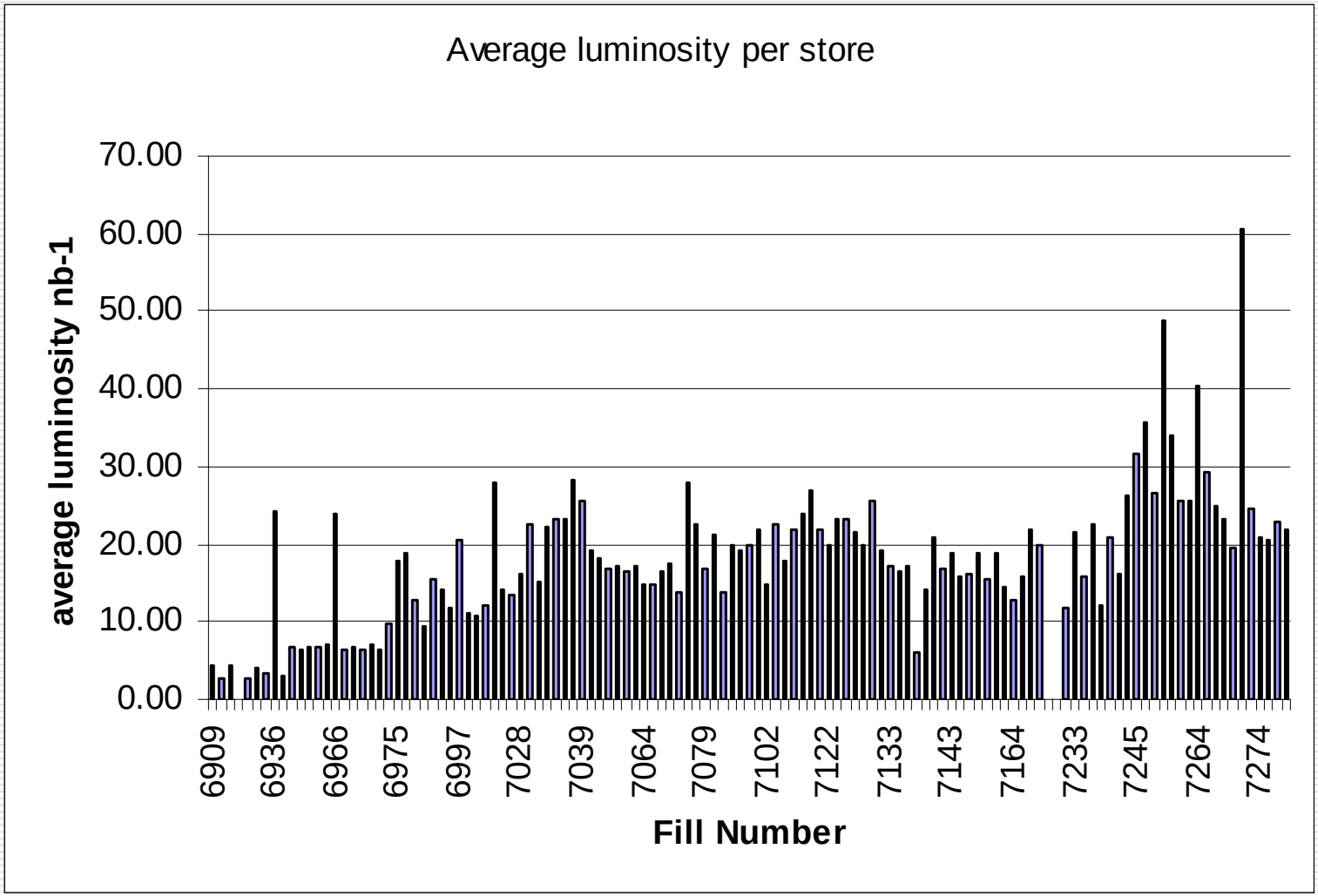
RHIC integrated luminosity: soft-physics-on ~ ev-lumi-off



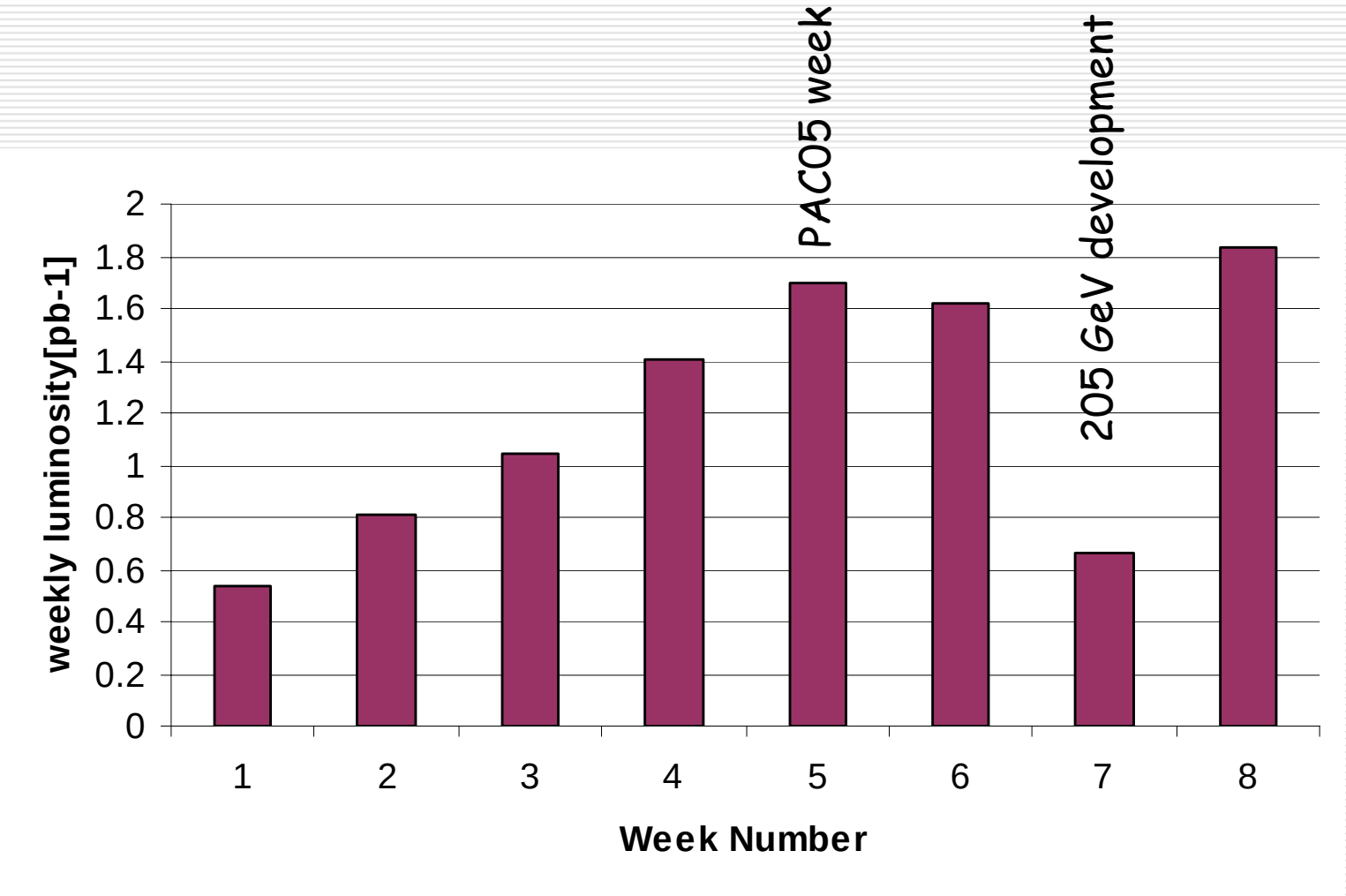
RHIC integrated FOM



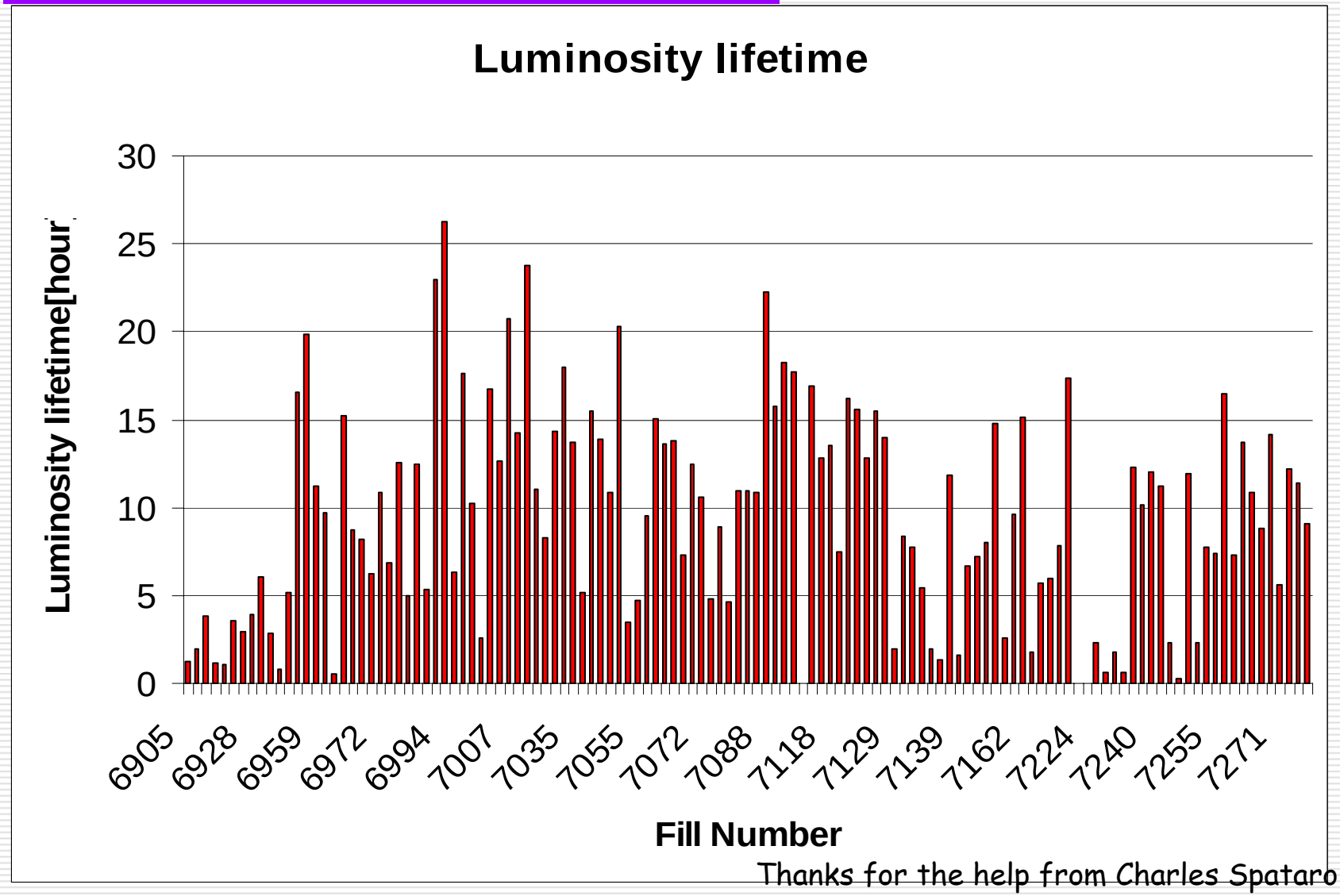
Average luminosity per store



Average luminosity per week

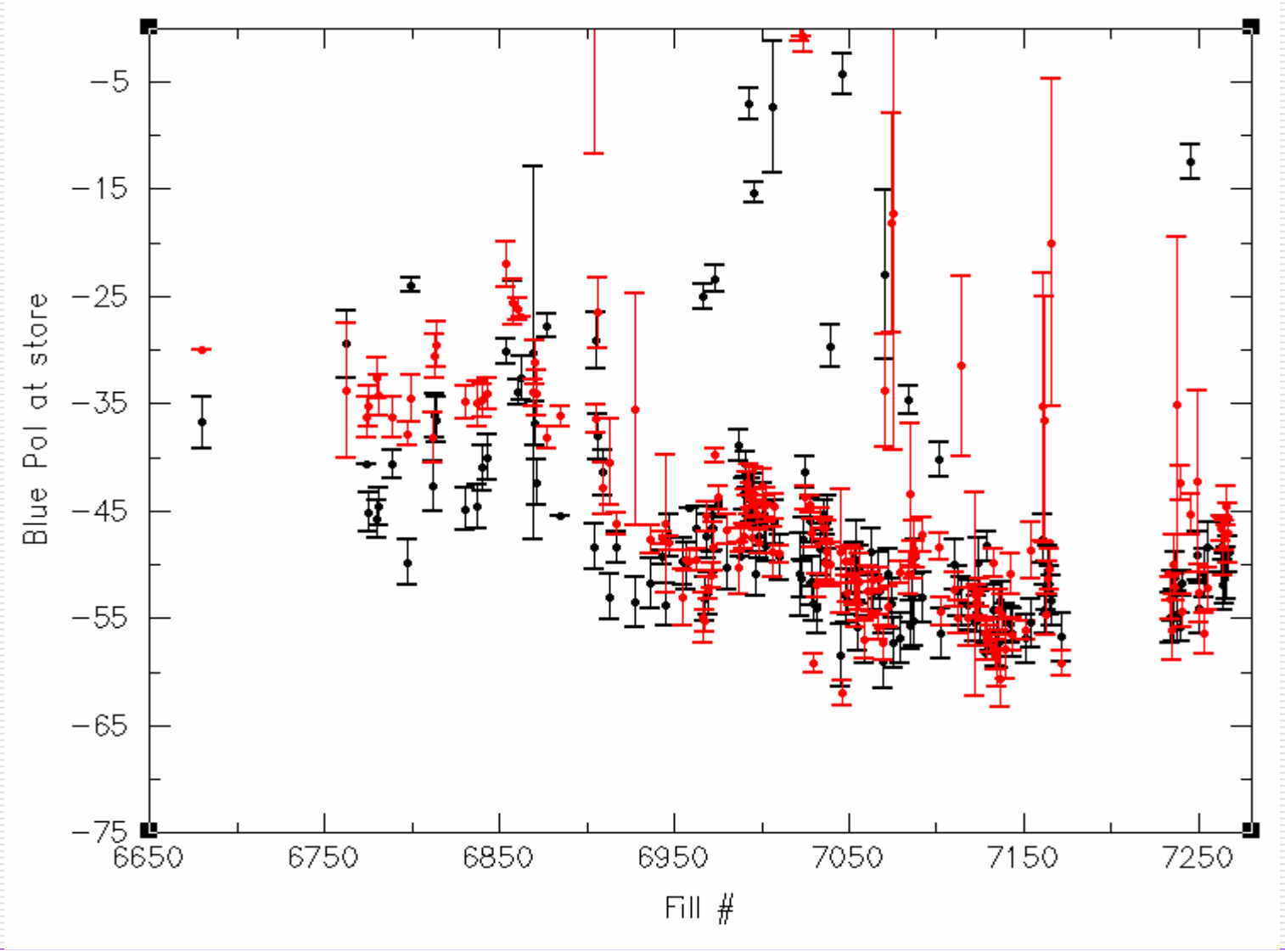


Luminosity lifetime

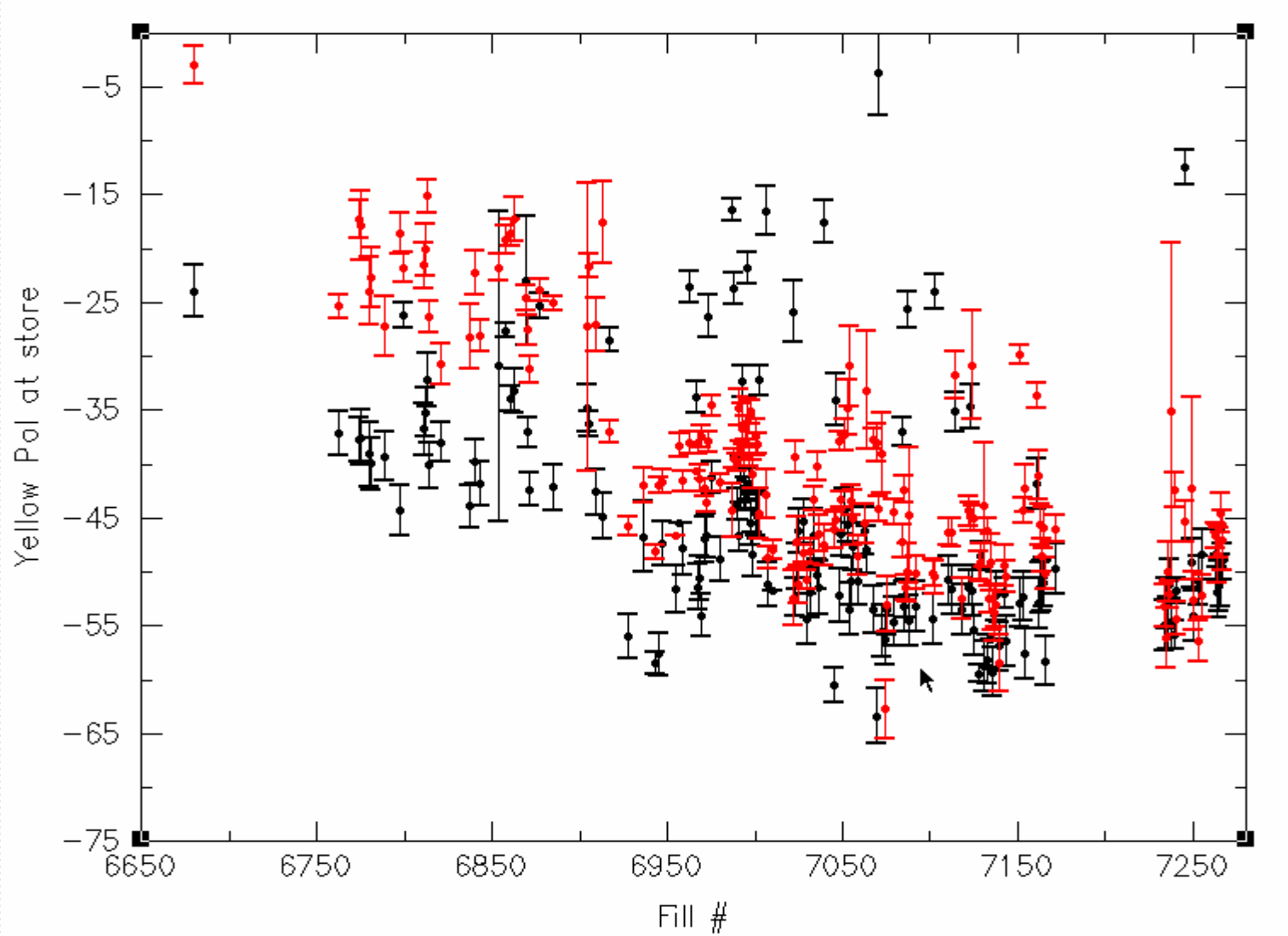


Thanks for the help from Charles Spataro

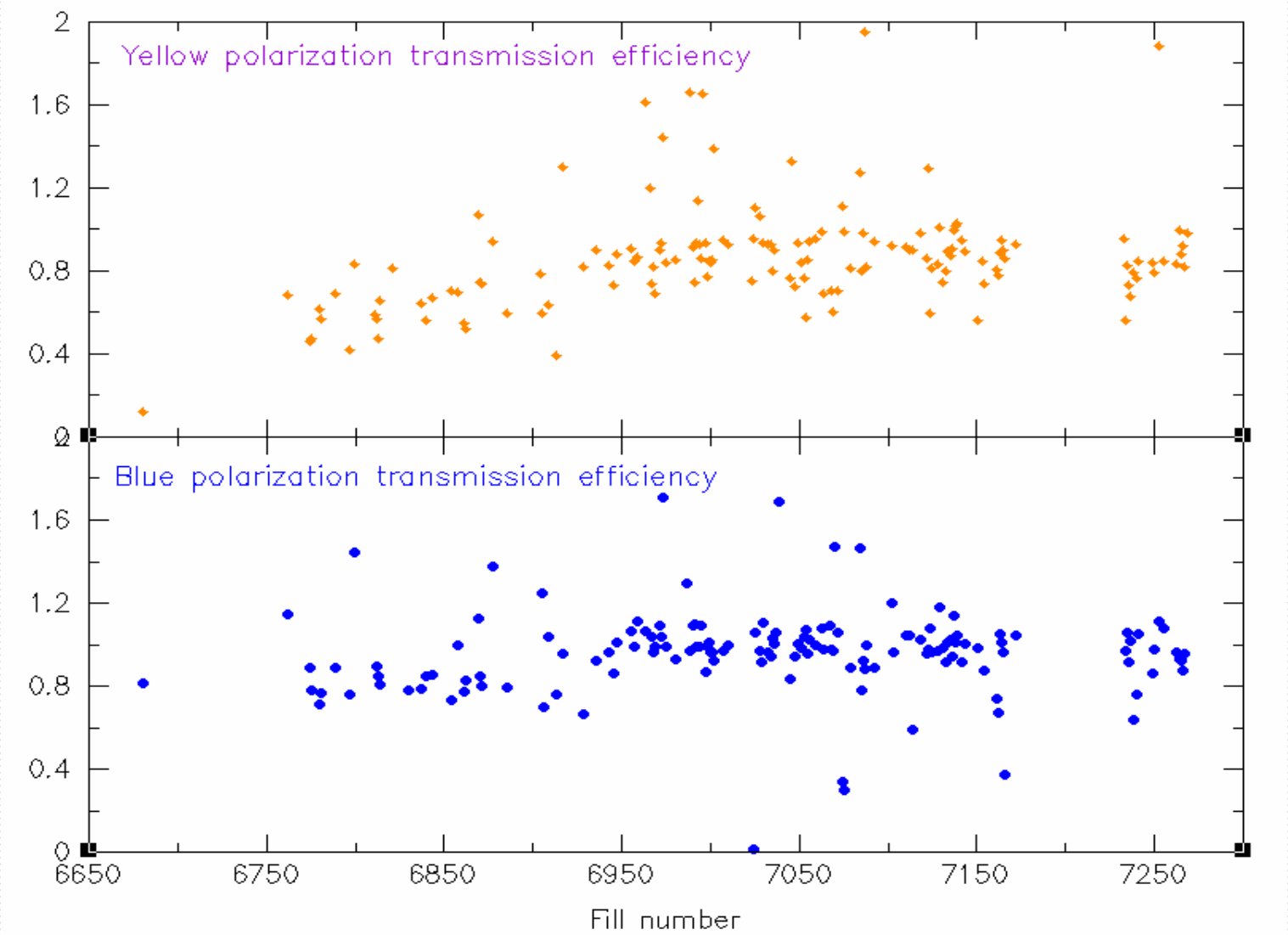
Achieved polarization in Blue



Achieved polarization in Yellow



Polarization efficiency

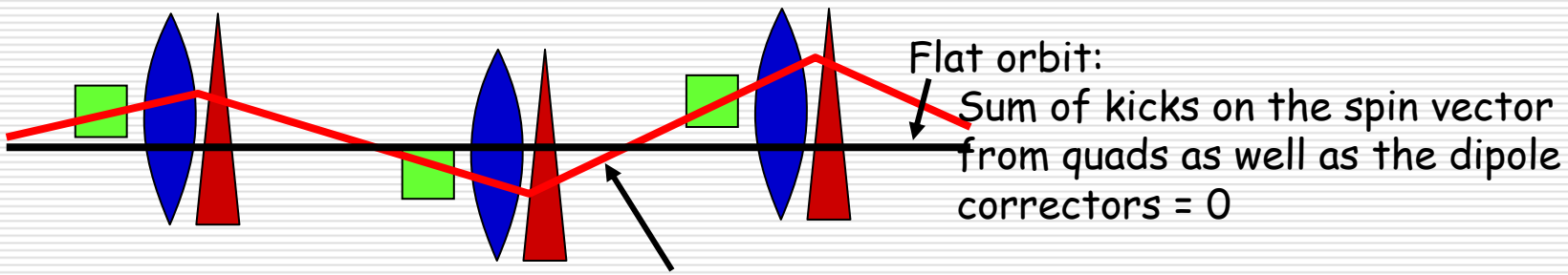


205 GeV development

- Beams were accelerated and collided at 205GeV
  - 30% polarization was measured in both rings at 205GeV
  - Two polarization ramp measurements
    - An increase of 1mm vertical rms in yellow decreased the polarization transmission efficiency by close to a factor of 2
    - Push the Qy away from 0.7 in Blue didn't affect the pol transmission efficiency

Issues during the run

- Polarimeter
  - Poor transition between new application and old application
    - Target protection
      - Target accidentally left in beam for close to 8 hours and caused the damage on the detector
  - Configuration control
    - Misleading polarization measurement, madness in chasing polarization in yellow
- flat orbit vs. zero orbit
  - No difference in polarization transmission efficiency
  - But, flat orbit introduces stronger coupling and an enhancement on a imperfection resonance at $G\gamma=85$



Issues during the run

- Beam lifetime at collision
  - Daily variation of orbit
  - Dispersion function sensitive to the local angle bump at IP6 and IP8
  - Sensitive to Brahms magnets configuration
  - Non-reproducible
  - Yellow vertical tune at store prefers to sit low
- STAR background issue
  - Reduce the efficiency at the beginning of the store
  - Sensitive to the local orbit
  - Prefer to sit slightly lower through the tripplets

Issues during the run

- Yellow injection kicker slow rising time
  - Cause emittance blowup of the bunches which are 3-buckets apart
  - Temporarily solved by adding an additional 10ns delay
- Diagnostics at store with beam-beam on
  - Artus is not quite effective in telling where the working point is at store with beam in collision
  - Schottky has become an promising tool in measuring the chromaticity at store. However, the absolute value still needs to be calibrated

Outlook for RUN06

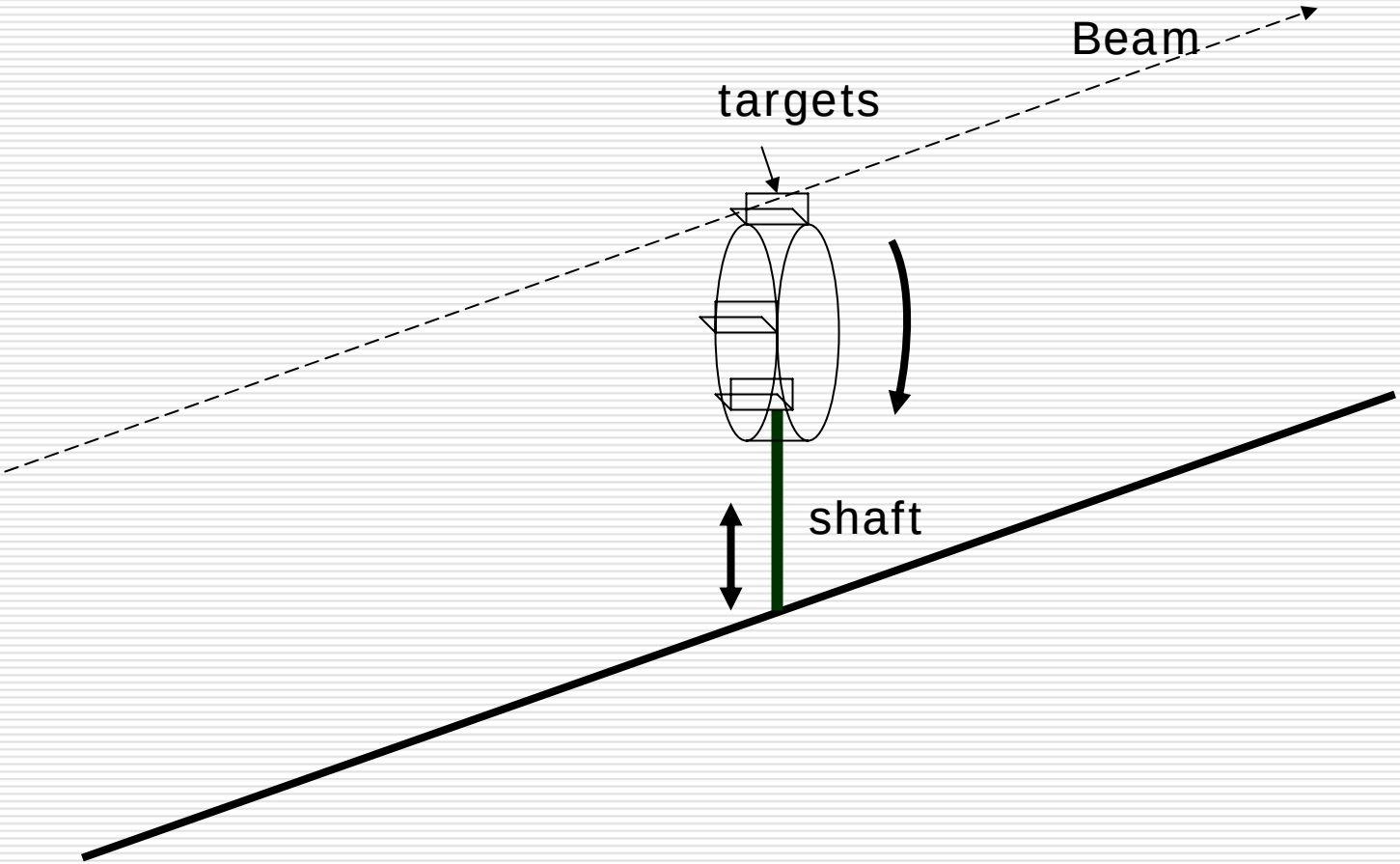
- Improve the beam-beam limit to allow 2×10^{11} protons per bunch
  - Offline data analysis/modeling to understand
    - Yellow dynamic aperture
    - Smaller beam-beam tune shift limit than expected
  - Wire compensation
- 110 bunches with 1×10^{11} protons per bunch
  - Improve the CNI polarimeter vacuum pressure
    - outgas before installation
- Improve the dispersion matching in the IR region to improve the dynamic aperture
  - Dispersion function measurements before the run ends
- Orbit feedback to fight against the orbit daily variation
- Machine re-alignment

Outlook for RUN06

- Procedures for reducing the time between the beginning of collisions and experiments' data taking
  - Collimation along the ramp
  - STAR shieldings
- Critical beam instrumentations
  - BPMs
    - Reliability
    - Beam based alignment
  - Schottky
    - Promising measurements in
      - Emittance, chromaticities and tunes
    - Best tool for monitoring beam parameters during store
    - Calibration of its emittance and chromaticity measurements

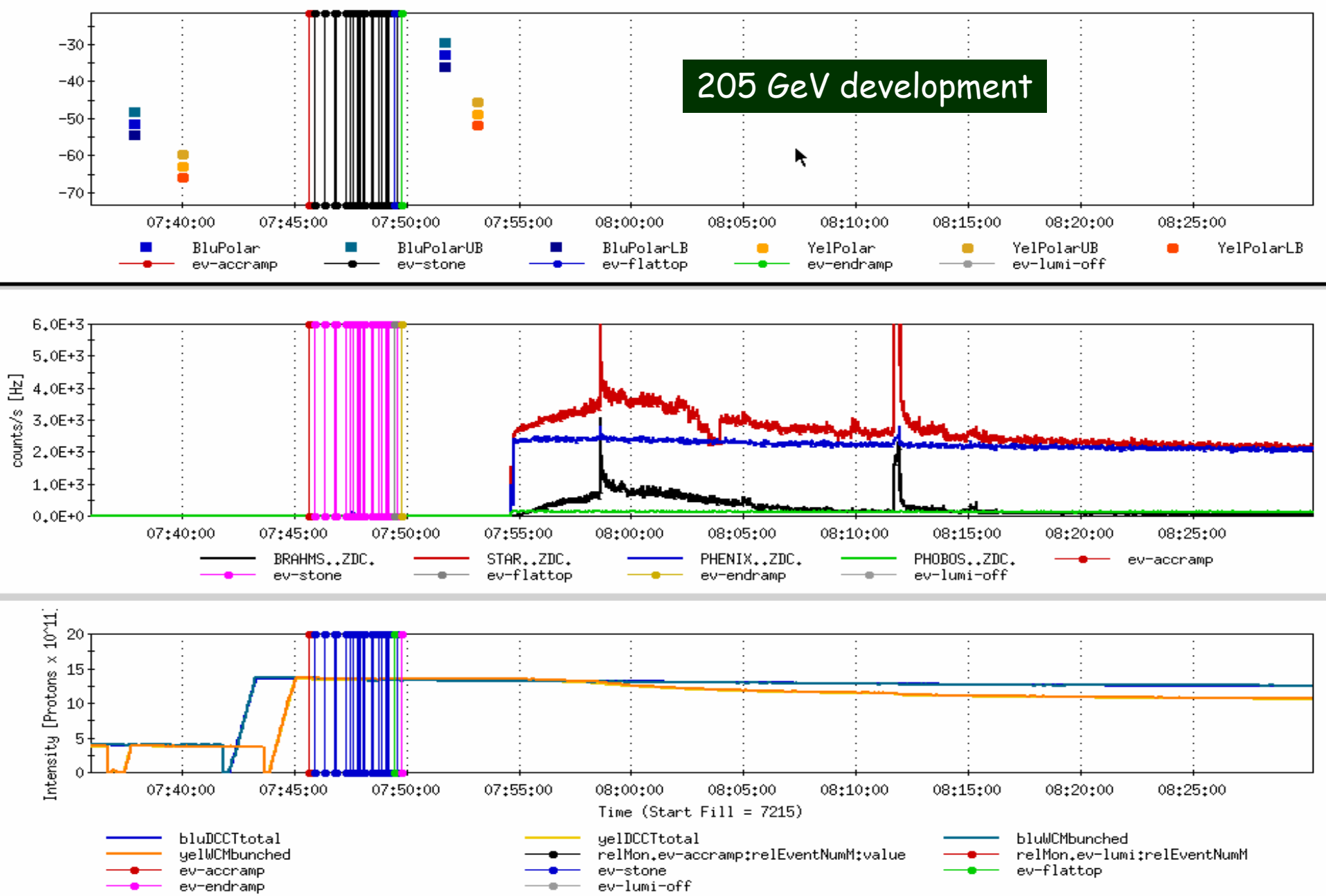
Outlook for RUN06

- Polarimeter, polarimeter, polarimeter…
  - Target requirements
    - Thin targets to reduce the radiation damage on the Si detectors
    - Maximize number of targets to reduce/avoid opening vacuum in the mid of run
    - Better reproducibility of the target position
      - A new design of mechanical target system
      - A dedicated bpm for CNI polarimeter
        - Avoid calculations for every polarization measurement
        - Also allows to build a system to automatically feedback the bpm signal to the target position. This will directly benefit the polarization ramp measurement.

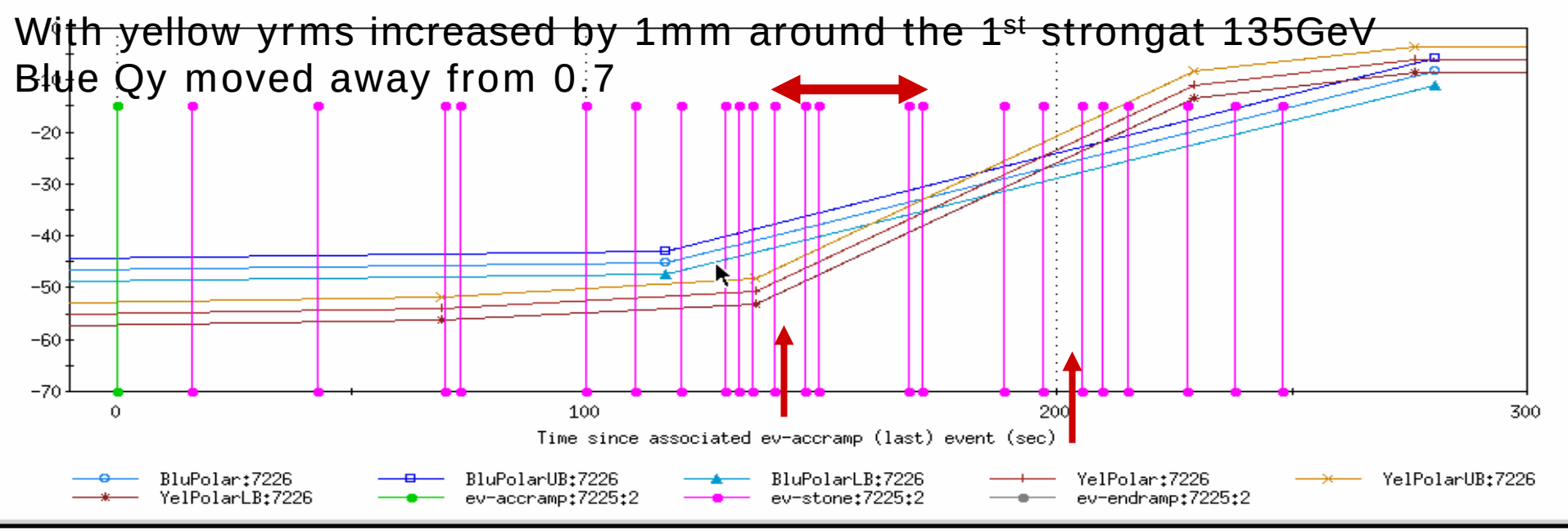

Beam
targets
shaft

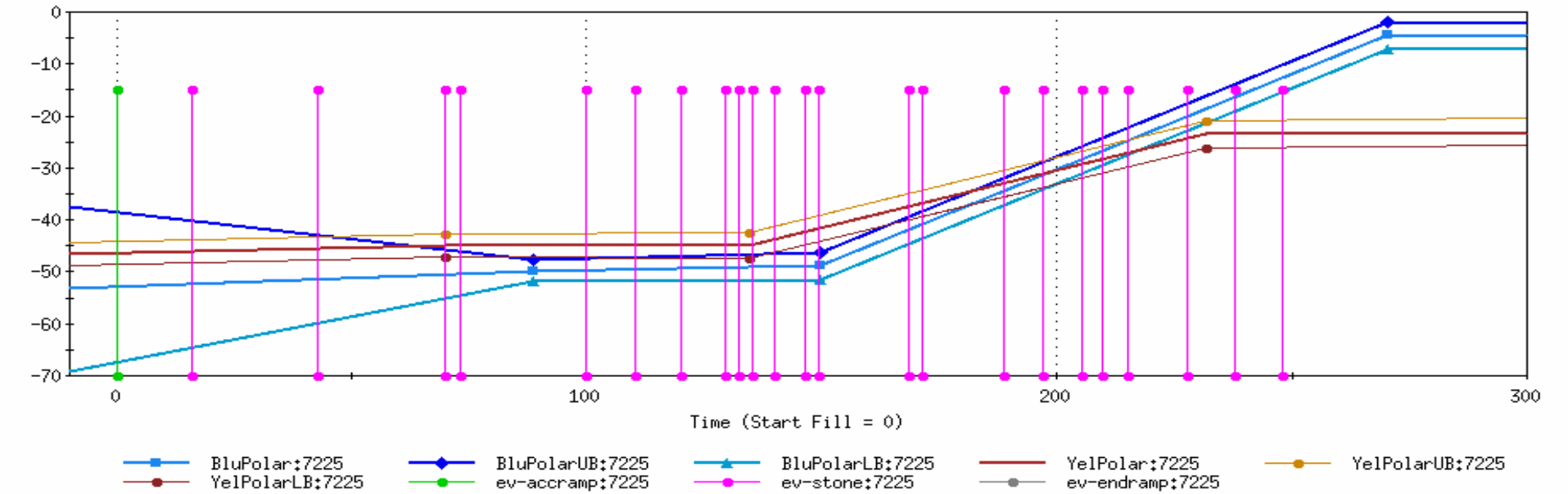
Acknowledgement

L. Ahrens, I.G. Alekseev, J. Alessi, J. Beebe-Wang, M. Blaskiewicz, A. Bravar, J.M. Brennan, D. Bruno. G. Bunce, J. Butler, P. Cameron, R. Connolly, J. Delong, T. D'Ottavio, A. Drees, W. Fischer, G. Ganetis, C. Gardner, J. Glenn, T. Hayes, H-C. Hseuh. H. Huang, P. Ingrassia, U. Iriso-Ariz, O. Jinnouchi, J. Laster, R. Lee, A. Luccio, Y. Luo, W.W. MacKay, Y. Makdisi, G. Marr, A. Marusic, G. McIntyre, R. Michnoff, C. Montag, J. Morris, A. Nicoletti, P. Oddo, B. Oerter, J. Piacentino, F. Pilat, V. Ptitsyn, T. Roser, T. Satogata, K. Smith, D.N. Svirida, S. Tepikian, R. Tomas, D. Trbojevic, N. Tsoupas, J. Tuozzolo, K. Vetter, M. Milinski. A. Zaltsman, A. Zelinski, K. Zeno, S.Y. Zhang, ...

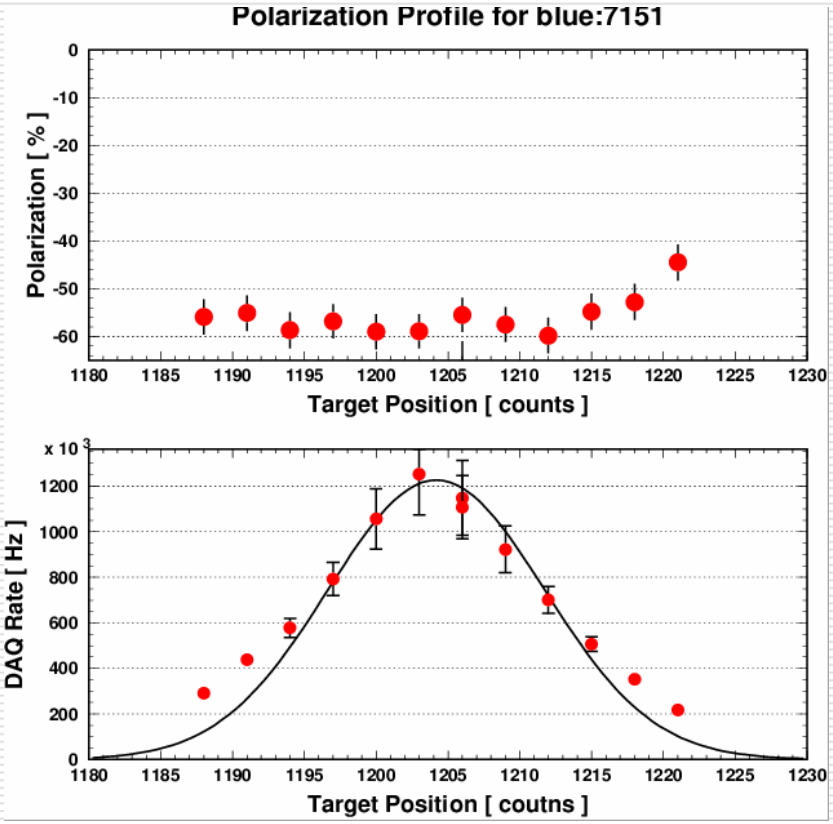

205 GeV development
-30
-40
-50
-60
-70
07:40:00
07:45:00
07:50:00
07:55:00
08:00:00
08:05:00
08:10:00
08:15:00
08:20:00
08:25:00
BluPolar
BluPolarUB
BluPolarLB
YelPolar
YelPolarUB
YelPolarLB
ev-accramp
ev-stone
ev-flattop
ev-endramp
ev-lumi-off
counts/s [Hz]
6.0E+3
5.0E+3
4.0E+3
3.0E+3
2.0E+3
1.0E+3
0.0E+0
BRAHMS..ZDC.
STAR..ZDC.
PHENIX..ZDC.
PHOBOS..ZDC.
Intensity [Protons x 10^11]
20
15
10
5
0
Time (Start Fill = 7215)
bluDCCTtotal
yelWCMbunched
yelDCCTtotal
relMon.ev-accramp:relEventNumM:value
bluWCMbunched
relMon.ev-lumi:relEventNumM

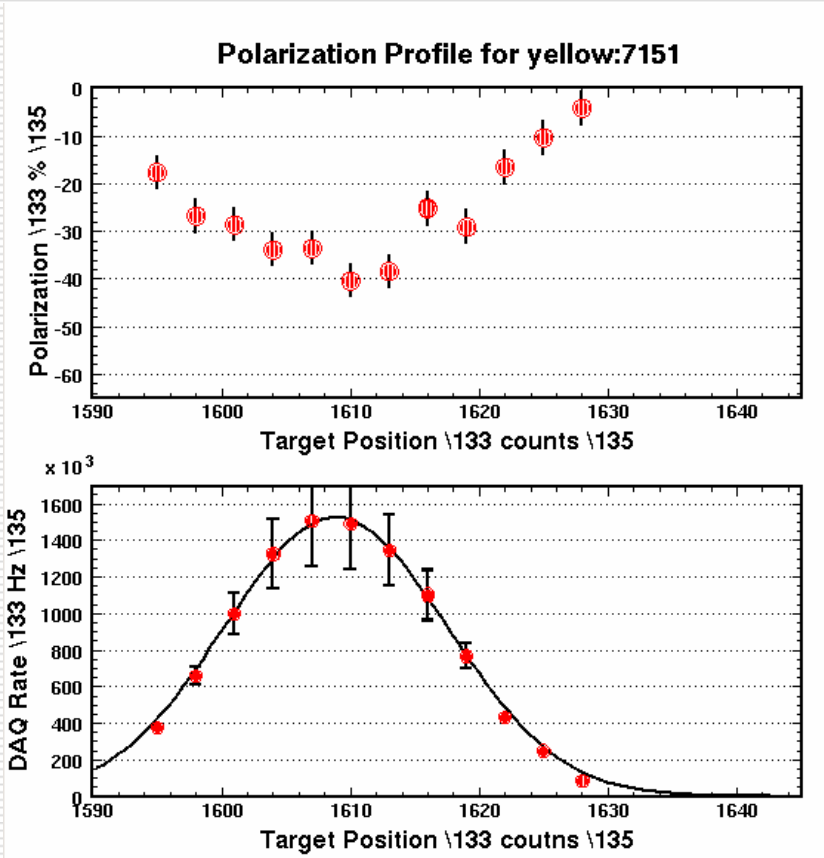
With yellow yrms increased by 1mm around the 1st strongat 135GeV
Blue Qy moved away from 0.7



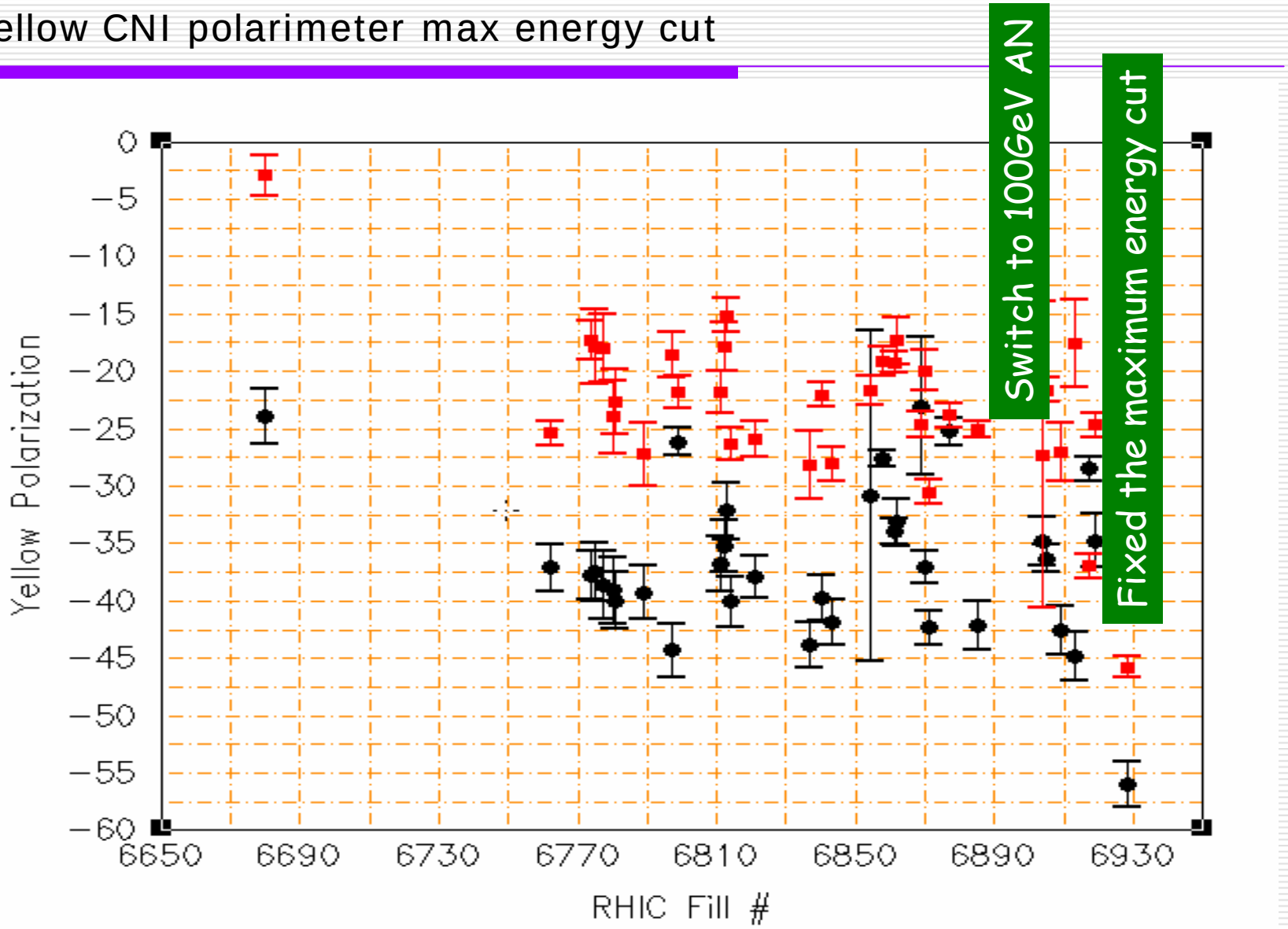


Polarization profile

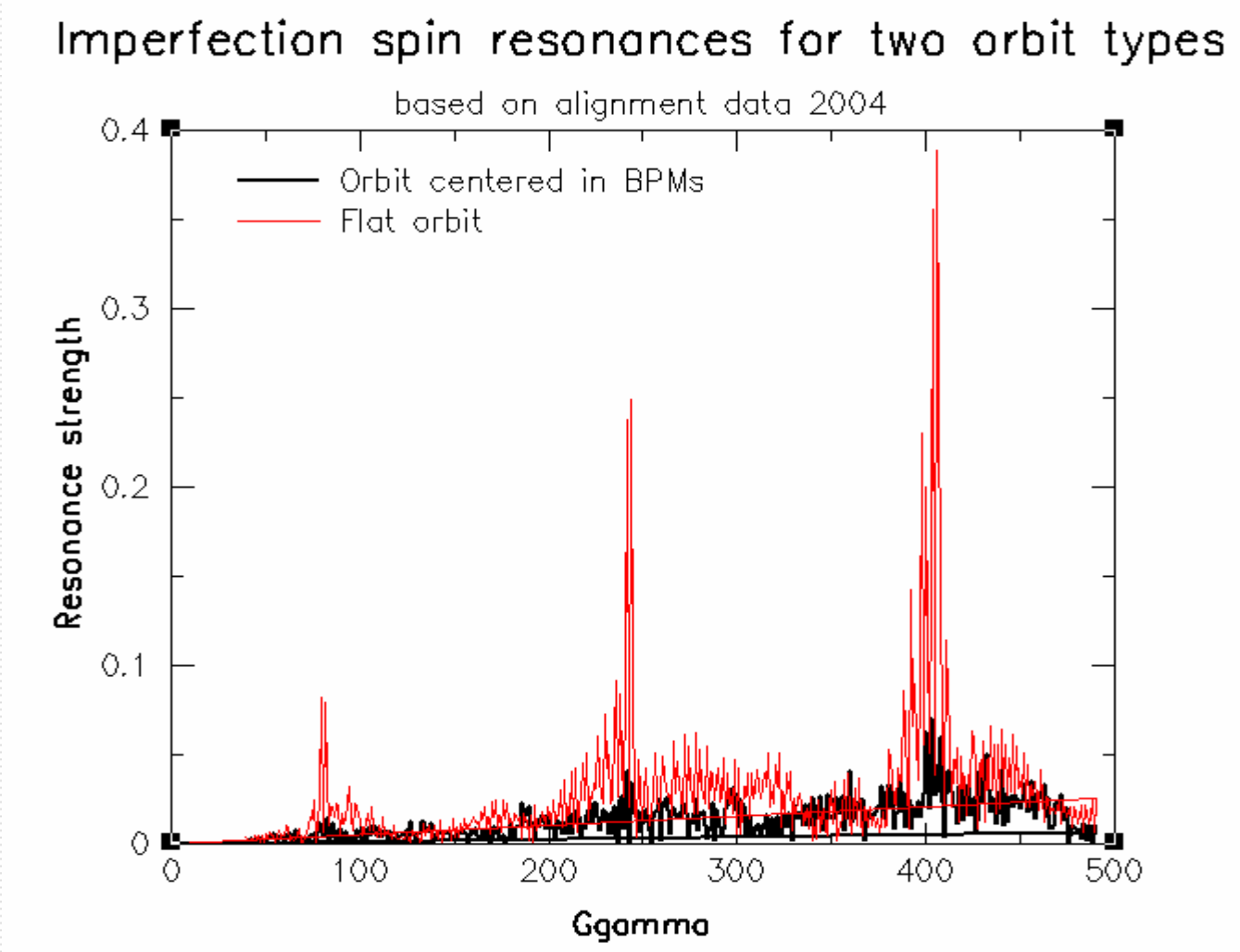




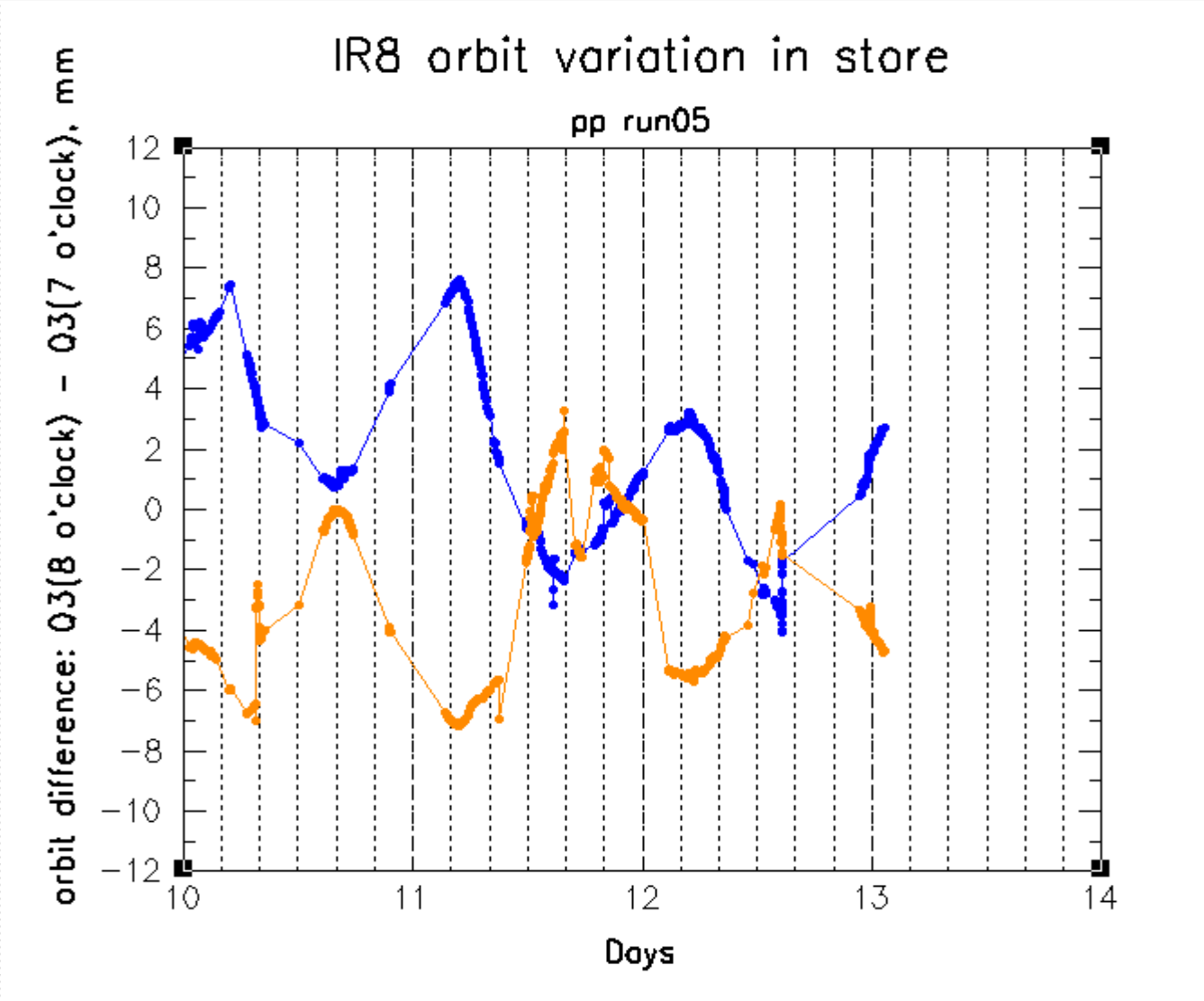
Yellow CNI polarimeter max energy cut



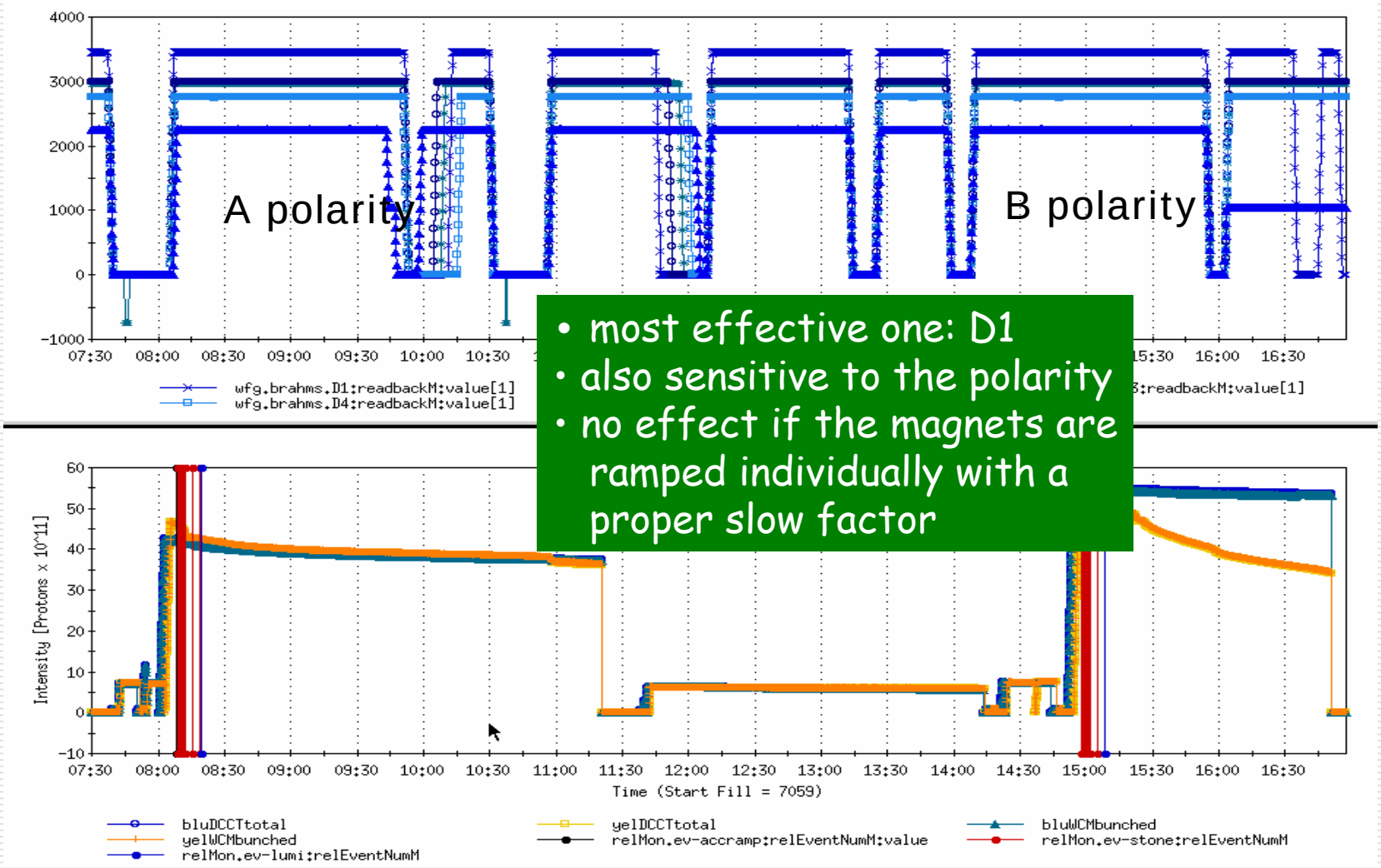
Imperfection resonance w. flat orbit



Orbit daily variation

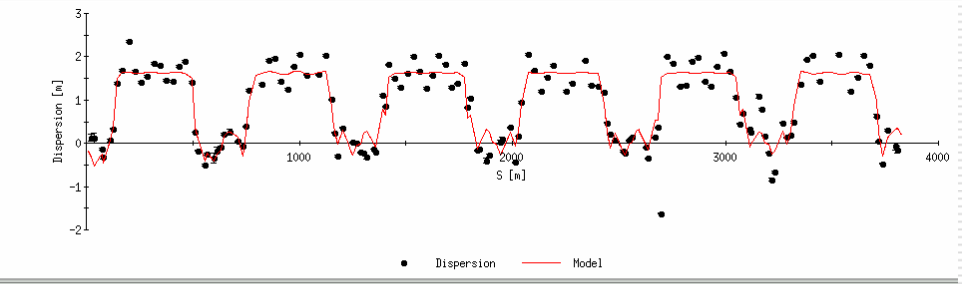


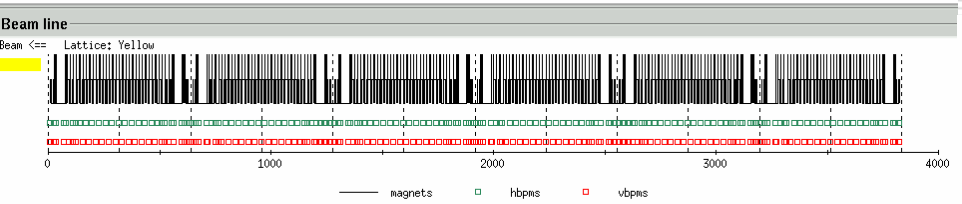
Effect of Brahms magnets

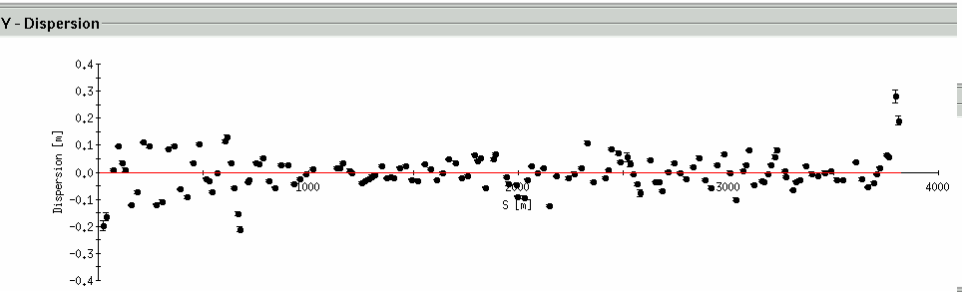


- most effective one: D1
- also sensitive to the polarity
- no effect if the magnets are ramped individually with a proper slow factor

Yellow dispersion function

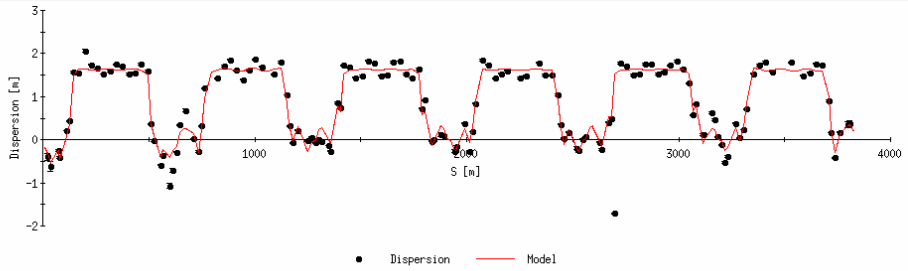


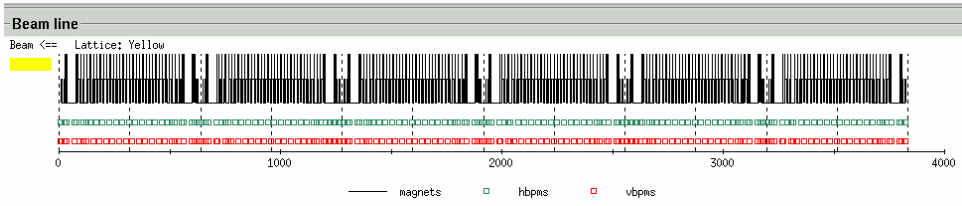


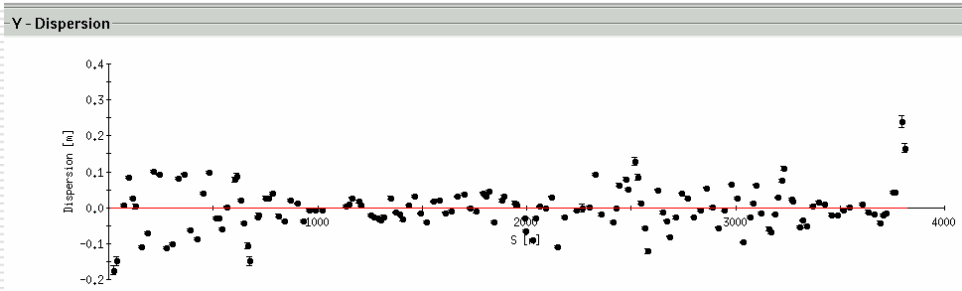


-0.28 mrad H bump

0 mrad H bump







STAR background